

Data-Driven Modeling of COVID-19 Transmission Dynamics: A Generalized SIR Framework

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Accurately modeling the transmission dynamics of COVID-19 at the population level remains a major challenge, especially in the face of behavioral changes, viral mutations, and public health interventions. In this work, we present a data-driven generalized Susceptible-Infected-Recovered (SIR) model designed to analyze publicly available epidemiological data from individual U.S. states. The model implicitly captures changes in transmission dynamics and intervention effects, enabling the reproduction of multiple epidemic waves associated with policy shifts and pathogen evolution. Furthermore, the framework estimates the time-varying effective reproduction number, providing valuable insights into the phases of epidemic expansion or contraction. We will discuss key mathematical properties of the model and demonstrate its applicability for real-time analysis and public health decision-making during the COVID-19 pandemic.

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